Summary: P229 #1-4,5-23

P229

1)
This simplifies calculations, as the molar masses of the compound, and that of the elements can be used to calculate percentage composition data.

2)
It is exactly the same as water found in nature, as all water has the same formula, H_2O, regardless of how it was created in the first place.

3)
a) Masses of CO_2 and H_2O generated during the combustion, as well as the mass of the original hydrocarbon burned.
b) Their results would be the same, and the C-H combustion analyzer provides data that can be used to calculate an empirical formula, not a molecular formula. Additional information obtained through other means is needed to calculate a molecular formula.

4)
No, there is not enough information to get an empirical formula in the first place, as the mole ratios of the elements must be known.

5) $M(Na_2B_4O_7)•10H_2O$ = 381.42 g/mol
$n(Na_2B_4O_7)$ = 5.00 g ÷ 381.42 g/mol = 0.0131 mol
therefore $n(H_2O)$ = 10 X 0.0131 mol = 0.131 mol
$m(H_2O)$ = 0.131 mol X 18.02 g/mol = 2.36 g
therefore $m(Na_2B_4O_7)$ = 5.00 g - 2.36 g = 2.64 g

6)
a) $M(CCl_2F_2)$ = 120.91 g/mol
%cm (C) = 12.01 g/mol ÷ 120.91 g/mol X 100% = 9.93 %
%cm (Cl) = 2 X 35.45 g/mol ÷ 120.91 g/mol X 100% = 58.6%
%cm (F) = 2 X 19.00 g/mol ÷ 120.91 g/mol X 100% = 31.4%

b) $M[Pb_3(OH)_2(CO_3)_2]$ = 776.15 g/mol
%cm (Pb) = 3 X 207.37 g/mol ÷ 776.15 g/mol X 100% = 80.2%
%cm (O) = 8 X 16.00 g/mol ÷ 776.15 g/mol X 100% = 16.5%
%cm (H) = 2 X 1.01 g/mol ÷ 776.15 g/mol X 100% = 0.260%
%cm (C) = 2 X 12.01 g/mol ÷ 776.15 g/mol X 100% = 3.09%

7)
a) $M(MgCl_2 \bullet 2H_2O)$ = 131.25 g/mol
$n(MgCl_2 \bullet 2H_2O)$ = 25.00g ÷ 131.25 g/mol = 0.1905 mol
$n(H_2O)$ = 2 X 0.1905 mol = 0.3810 mol
$m(H_2O)$ = 0.3810 mol X 18.02 g/mol = 6.866 g

b) $M(KMnO_4)$ = 158.04 g/mol
%cm (Mn) = 54.94 g/mol ÷ 158.04 g/mol X 100% = 34.76%
m(Mn) = 34.76% X 5.00 g = 1.74 g

8)
a) $M(AgNO_3)$ = 169.88 g/mol
%cm (Ag) = 107.87 g/mol ÷ 169.88 g/mol X 100% = 63.50%

b) m(Ag) = 63.50% 2.00 X 10^2 kg = 127 kg

9)
$M(BaSO_4)$ = 233.40 g/mol
%cm (Ba) = 137.33 g/mol ÷ 233.40 g/mol X 100% = 58.84%
m(Ba) = 58.84% X 45.8 g = 26.9 g

10)
$M[Bi(NO_3)_2]$ = 333.00 g/mol
%cm (Bi) = 208.98 g/mol ÷ 333.00 g/mol X 100% = 62.76%
m(Bi) = 62.76% X 268 g = 168 g

11)
M(Empirical) = 30.03 g/mol
M(Molecular) ÷ M(Empirical) = 121 g/mol ÷ 30.03 g/mol = 4
Therefore, molecular formula is $4(CH_2O) = C_4H_8O_4$

12)
$M(C_6H_2OCl_2)$ = 160.98 g/mol
M(Molecular) ÷ M(Empirical) = 322 g/mol ÷ 160.98 g/mol = 2
Therefore, molecular formula is $2(C_6H_2OCl_2) = C_{12}H_4O_2Cl_4$

13)
a) A formula cannot have a fractional subscript, as this implies fractional atoms in a formula.
b) empirical formula = $3(CH_{2.67}) = C_3H_8$

14)

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
C	80.2	12.01	6.67	10.5	21
H	9.62	1.01	9.54	15	30
O	10.18	16.00	0.636	1	2

Therefore, the empirical formula of progesterone is $C_{21}H_{30}O_2$

15)

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
Na	17.6	22.99	0.766	1	2
Cr	39.7	52.00	0.763	1	2
O	42.8	16.00	2.67	3.5	7

Therefore, the empirical formula is $Na_2Cr_2O_7$

16)

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
Hg	67.6	200.59	0.337	1	1
S	10.8	32.07	0.337	1	1
O	21.6	16.00	2.00	4	4

Therefore, the empirical formula is $HgSO_4$

17)
a)

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
Ca	38.8	40.08	0.968	1.5	3
P	20.0	30.97	0.646	1	2
O	41.2	16.00	2.575	4	8

Therefore, the empirical formula is $Ca_3P_2O_8$

b) Since each formula unit as 2 P, and so does the empirical formula, the molecular formula is most likely the same. It is more recognizable as $Ca_3(PO_4)_2$.

18)
a)

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
C	71.0	12.01	5.91	18	18
H	8.60	1.01	8.51	26	26
O	15.8	16.00	0.988	3	3
N	4.60	14.01	0.328	1	1

Therefore, the empirical formula of Capsaicin is $C_{18}H_{26}O_3N$

b) Since both the empirical and molecular formulas contain one N, the molecular formula is the same as the empirical formula $C_{18}H_{26}O_3N$.

19)
Create a table as for empirical formula and work backwards to determine the molar mass of X, therefore identifying it.

Element	Mass (%)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
X	56.00	??????	1.1	2	2
O	44.00	16.00	2.75	5	5

Therefore, M = 56.00g ÷ 1.1 mol = 50.91.
V, with a M=50.94, is the closest. A formula of V_2O_5 is a valid formula!

20)
m(H from HCl) = 4.730g X 1.01g/mol ÷ 36.46 g/mol = 0.131 g
m(C from CCl_4) = 9.977g X 12.01 g/mol ÷ 153.81 g/mol = 0.7790 g
m(O) = 1.254 g - 0.131 g - 0.7790 g = 0.344 g

Element	Mass (g)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
C	0.7790	12.01	0.06486	3	3
H	0.131	1.01	0.130	6	6
O	0.344	16.00	0.0215	1	1

Therefore, the empirical formula is C_3H_6O

21)
m($FeSO_4$) = 1.52 g
n($FeSO_4$) = 1.52 g ÷ 151.92 g/mol = 0.0100 mol
m(H_2O) = 2.78 g - 1.52 g = 1.26 g
n(H_2O) = 1.26 g ÷ 18.02 g/mol = 0.0699
mole ratio = 7:1
Therefore, there are 7 water molecules for every formula unit of iron(II) sulfate.

22)
a)
m(C) from CO_2 = 0.6871 g X 12.01 g/mol ÷ 44.01 g/mol = 0.1875 g
m(H) from H_2O = 0.1874 g X 2.02 g/mol ÷ 18.02 g/mol = 0.02101 g
m(O) = 0.5000 g - 0.1875 g - 0.02101 g = 0.2915 g

%cm (C) = 0.1875 g / 0.5000 g X 100% = 37.50%
%cm (H) = 0.02101 g / 0.5000 g X 100% = 4.202%
%cm (O) = 0.2915 g / 0.5000 g X 100% = 58.30%

b)

Element	Mass (g)	M(g/mol)	n(mol)	mole ratio	mole ratio in whole numbers
C	0.1875	12.01	0.01561	1	6
H	0.02101	1.01	0.02081	1.33	8
O	0.2915	16.00	0.01822	1.167	7

Therefore, empirical formula of citric acid is $C_6H_8O_7$

c) M(empirical) = 192.14 g/mol
M(molecular) = 192 g/mol
Therefore, molecular formula of citric acid is $C_6H_8O_7$.

23)
M(methanol) = 32.05 g/mol
%cm (C) = 12.01 g/mol ÷ 32.05 g/mol X 100% = 37.47%
%cm (H) = 4.04 g/mol ÷ 32.05 g/mol X 100% = 12.61%
%cm (O) = 16.00 g/mol ÷ 32.05 g/mol X 100% = 49.92%

m(C) in methanol = 1.00g X 37.47% = 0.3747 g
m(H) in methanol = 1.00g X 12.61 % = 0.1261 g
therefore,
m(CO_2) = 0.3747g X 44.01 g/mol ÷ 12.01 g/mol = 1.373 g
m(H_2O) = 0.1261 g X 18.02 g/mol ÷ 2.02 g/mol = 1.125 g